

WHAT IS CLAIMED IS:

1. An audio reproduction system comprising:

a first audio input signal, a second audio input signal, a third audio input signal, and a fourth audio input signal;

a left main speaker and a right main speaker intended to be disposed respectively at left and right main speaker locations spaced along a speaker axis defined as a line passing through said left and right main speaker locations, with a listening area comprising the general area in front of the left and right main speaker locations such that the left main speaker location lies to the left and the right main speaker location lies to the right when viewed from the listening area, wherein said left and right main speakers reproduce sound associated with signals received by said left and right main speakers;

a left sub-speaker and a right sub-speaker intended to be disposed respectively at left and right sub-speaker locations, wherein the intended left and right sub-speaker locations are intended to lie approximately on the speaker axis such that the left and right sub-speaker locations as viewed from the listening area are located to the left and right respectively of the respective left and right main speaker locations and are spaced a distance  $d$  from the respective left and right main speaker locations such that the distance  $d$  is in the range from approximately 50% to 150% of the average spacing between a person's ears as measured in a straight line through the head, wherein said left and right sub-speakers reproduce sound associate with signals received by them; and

signal modification and combination means, wherein said signal modification and combination means comprises,

means for modifying and combining the first audio input signal with the second audio input signal and transmitting the combination of said modified first audio input signal and said second audio input signal to said left main speaker,

means for modifying and combining the fourth audio input signal with the third audio input signal and transmitting the combination of said modified fourth audio input signal and said third audio input signal to said right main speaker,

means for subtracting said modified fourth audio input signal from said modified first audio input signal and transmitting the resulting difference signal to said left sub-speaker, and

means for subtracting said modified first audio input signal from said modified fourth audio input signal and transmitting the resulting difference signal to said right sub-speaker,

wherein sound reproduced by the system that is associated with said second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a range of sound locations approximately between said left and right main speakers, and

wherein sound reproduced by the system that is associated with said first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers.

2. The audio reproduction system of claim 1 further comprising:

a fifth audio input signal;

a center front speaker intended to be located between the left and right main speaker locations, wherein said center front speaker reproduces sound associated with signals received by it; and

means for transmitting said fifth audio input signal to said center front speaker,

wherein sound reproduced by the system associated with said fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from approximately the location of said center front speaker.

3. The audio reproduction system of claim 1 or 2, wherein the distance  $d$  between said respective main and sub-speakers is approximately equal to the average ear spacing.

4. The audio reproduction system of claim 1, wherein said signal modification and combination means further includes a first front-to-back filter for modifying the first audio input signal and a second front-to-back filter for modifying the fourth audio input signal such that the reproduced sound associated with said first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers including areas behind the listener.

5. The audio reproduction system of claim 1 or 2, wherein said first audio input signal, said second audio input signal, said third audio input signal, and said fourth audio input signal correspond to rear left, front left, front right, and rear right signals of a surround sound audio system.

6. The audio reproduction system of claim 4, wherein the first and second front-to-back filters are band limited to below approximately 2,500 Hz.

7. The audio reproduction system of claim 4, wherein the first and second front-to-back filters include band emphasis at approximately 12 kHz.

8. The audio reproduction system of claim 1 or 2, wherein the signal modification and combination means further includes a first low-pass filter for modifying the portion of the modified first audio input signal transmitted to the left sub-speaker and a second low-pass filter for modifying the portion of the modified fourth audio input signal transmitted to the right sub-speaker,

wherein the apparent sound locations of sound reproduced by the system associated with said first and fourth audio input signals are perceived by a listener located in the listening area to be more stable and more tolerant of movements of the listener's head.

9. The audio reproduction system of claim 8, wherein said first and second low-pass filters limit frequency response to below approximately 5 kHz.

10. The audio reproduction system of claim 8, wherein said first and second low-pass filters limit frequency response to below approximately 1.8 kHz.

11. The audio reproduction system of claim 8, wherein said first and second low-pass filters limit frequency response to below approximately 1 kHz.

12. The audio reproduction system of claim 8, wherein the signal modification and combination means further includes a third low-pass filter for modifying that portion of the modified first audio input signal subtracted from the modified fourth audio input signal and a fourth low-pass filter for modifying that portion of the modified fourth audio input signal subtracted from the modified first audio input signal,

wherein the apparent sound locations of sound reproduced by the system associated with said first and fourth audio input signals are perceived by a listener located in the listening area to be more stable and more tolerant of movements of the listener's head.

13. The audio reproduction system of claim 1 or 2, wherein the signal modification and combination means further includes:

a first high-pass filter for modifying the portion of the modified first audio input signal which is subtracted from the modified fourth audio input signal prior to transmission to the right sub-speaker; and

a second high-pass filter for modifying the portion of the modified fourth audio input signal which is subtracted from the modified first audio input signal prior to transmission to the left sub-speaker,

wherein the resulting signals received by the left and right sub-speakers have low-frequency content primarily composed of information only from the first and fourth audio input signals, respectively.

14. The audio reproduction system of claim 1, further comprising a fifth audio input signal,

wherein the signal modification and combination means further includes means for combining said fifth audio input signal with the signals being received by the left and right main speakers, and

wherein in addition to the signals specified in claim 1, the left and right main speakers also receive approximately equal quantities of said fifth audio input signal, and

wherein sound reproduced by the system associated with said fifth audio input signal is perceived by a listener located in the listening area to originate approximately from a location equidistant between the left and right main speakers.

15. The audio reproduction system of claim 14, further comprising a sixth audio input signal,

wherein the signal modification and combination means further includes,

a front-to-back filter for modifying the sixth audio input signal, and

means for combining the modified sixth audio input signal with the signals being received by the left and right main speakers,

wherein in addition to the signals specified in claim 14, the left and right main speakers also receive approximately equal quantities of said modified sixth audio input signal, and

wherein sound reproduced by the system associated with said sixth audio input signal is perceived by a listener located in the listening area to originate from a location generally behind the listener.

16. The audio reproduction system of claim 4, wherein said signal modification and combination means further comprises:

means for combining the second audio input signal with the first audio input signal after modification of said first audio input signal by a first front-to-back filter;

means for combining the third audio input signal with the fourth audio input signal after modification of said fourth audio input signal by a second front-to-back filter;

means for subtracting the combination of the modified fourth audio input signal and the third audio input signal from said combination of the modified first audio input signal and the second audio input signal and for transmitting the resulting difference signal to said left sub-speaker; and

means for subtracting the combination of the modified first audio input signal and the second audio input signal from said combination of the modified fourth audio input signal and the third audio input signal and for transmitting the resulting difference signal to said right sub-speaker,

wherein sound reproduced by the system associated with said second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations generally in front of the listener location and extending beyond said left and right sub-speakers, and

wherein sound reproduced by the system associated with said first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers and including the area behind the listener.

17. The audio reproduction system of claim 16, wherein the signal modification and combination means further includes:

a first low-pass filter for modifying the portion of the combined modified first and second audio input signal transmitted to the left sub-speaker; and

a second low-pass filter for modifying the portion of the combined modified third and fourth audio input signal transmitted to the right sub-speaker,

wherein the apparent sound locations of sound reproduced by the system associated with said first, second, third and fourth audio input signals are perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to be more stable and more tolerant of movements of the listener's head.

18. The audio reproduction system of claim 17, wherein said first and second low-pass filters limit frequency response to below approximately 5 kHz.

19. The audio reproduction system of claim 17, wherein said first and second low-pass filters limit frequency response to below approximately 1.8 kHz.



20. The audio reproduction system of claim 17, wherein said first and second low-pass filters limit frequency response to below approximately 1 kHz.

21. The audio reproduction system of claim 17, wherein the signal modification and combination means further includes:

a third low-pass filter for modifying that portion of the combined modified first and second audio input signal subtracted from the combined modified third and fourth audio input signal; and

a fourth low-pass filter for modifying that portion of the combined modified third and fourth audio input signal subtracted from the combined modified first and second audio input signal,

wherein the apparent sound locations of sound reproduced by the system associated with said first, second, third and fourth audio input signals are perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to be more stable and more tolerant of movements of the listener's head.

22. The audio reproduction system of claim 16, wherein the signal modification and combination means further includes:

a first high-pass filter for modifying that portion of the combined modified first and second audio input signals which is subtracted from the combined modified third and fourth audio input signals prior to reproduction by the right sub-speaker; and

a second high-pass filter for modifying that portion of the combined modified third and fourth audio input signals which is subtracted from the combined modified first and second audio input signals prior to reproduction by the left sub-speaker,

wherein the resulting signal received by the left sub-speaker has low-frequency content primarily composed of information only from the combined modified first and second audio input signals, and

wherein the resulting signal received by the right sub-speaker has low-frequency content primarily composed of information only from the combined and modified third and fourth audio input signals.

23. The audio reproduction system of claim 16, further comprising a fifth audio signal input, wherein the signal modification and combination means further includes means for combining said fifth audio input signal with the signals being received by the left and right main speakers,

wherein in addition to the signals specified in claim 16, the left and right main speakers also receive approximately equal quantities of said fifth audio input signal, and

wherein sound reproduced by the system associated with said fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate approximately from a location equidistant between the left and right main speakers.

24. The audio reproduction system of claim 23, further comprising a sixth audio input signal, wherein the signal modification and combination means includes:

a front-to-back filter for modifying the sixth audio input signal; and

means for combining the modified sixth audio input signal with the signals being received by the left and right main speakers,

wherein in addition to the signals specified in claim 23, the left and right main speakers also receive approximately equal quantities of said modified sixth audio input signal, and

wherein sound reproduced by the system associated with said sixth audio input signal is perceived by a listener whose head is located generally at the listening location to originate from a location generally behind the listener.

25. An audio reproduction system comprising:

a first audio input signal, a second audio input signal, a third audio input signal, and a fourth audio input signal;

a left main speaker and a right main speaker intended to be disposed respectively at left and right main speaker locations spaced along a speaker axis defined as a line passing through said left and right main speaker locations, with a listening area comprising the general area in front of the left and right main speaker locations such that the left main speaker location lies to the left and the right main speaker location lies to the right when viewed from the listening area, wherein said left and right main speakers reproduce sound associated with signals received by them;

a left front speaker and a right front speaker intended to be located respectively at left and right front speaker locations generally in front of a listener in the listening area, wherein said left and right front speakers reproduce sound associated with signals received by them;

a left sub-speaker and a right sub-speaker intended to be disposed respectively at left and right sub-speaker locations, wherein the intended left and right sub-speaker locations are intended to lie approximately on the speaker axis such that the left and right sub-speaker locations as viewed from the listening area are located to the left

and right respectively of the respective left and right main speaker locations and are spaced a distance  $d$  from the respective left and right main speaker locations such that the distance  $d$  is in the range from approximately 50% to 150% of the average spacing between a person's ears as measured in a straight line through the head, wherein said left and right sub-speakers reproduce sound associated with signals received by them; and

signal modification and combination means, wherein said signal modification and combination means comprises,

means for transmitting the second audio input signal to the left front speaker and the third audio input signal to the right front speaker;

means for modifying the first audio input signal and transmitting the modified first audio input signal to said left main speaker,

means for modifying fourth audio input signal and transmitting the modified fourth audio input signal to said right main speaker,

means for subtracting the modified fourth audio input signal from the modified first audio input signal and transmitting the resulting difference signal to said left sub-speaker, and

means for subtracting the modified first audio input signal from the modified fourth audio input signal and transmitting the resulting difference signal to said right sub-speaker,

wherein sound reproduced by the system associated with said second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a range of sound locations approximately between said left front speaker and said right front speaker, and

wherein sound reproduced by the system that is associated with said first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers.

26. The audio reproduction system of claim 25, further comprising a fifth audio input signal,

wherein the signal modification and combination means further includes means for combining said fifth audio input signal with the signals being received by said left front speaker and said right front speaker,

wherein in addition to the signals specified in claim 25, the left and right front speakers also receive and reproduce approximately equal quantities of said fifth audio input signal, and

wherein sound reproduced by the system associated with said fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate approximately from a location equidistant between the left and right front speakers.

27. The audio reproduction system of claim 26, further comprising a sixth audio input signal, wherein the signal modification and combination means further includes:

a front-to-back filter for modifying the sixth audio input signal; and

means for combining the modified sixth audio input signal with the signals being received by the left and right front speakers,

such that in addition to the signals specified in claim 26, the left and right front speakers also receive approximately equal quantities of said modified sixth audio input signal, and

such that the reproduced sound associated with said sixth audio input signal is perceived by a listener whose head is located generally at the listening location to originate from a location generally behind the listener.

28. The audio reproduction system of claim 1 or 16, further comprising:

means for accepting a two-channel audio input signal; and

two channel to multi-channel conversion means for converting said two-channel audio input signal into a multi-channel audio output comprising at least four audio output signals; and

means for transmitting said at least four audio output signals to the at least four audio signal inputs of the signal modification and combination means.

29. The audio reproduction system of claim 1 or 16, further comprising:

means for accepting a two-channel audio input signal;

a two channel to multi-channel converter for converting said two-channel audio input signal into a multi-channel audio output comprising five audio output signals;

means for transmitting four of the audio output signals to the four audio signal inputs of the signal modification and combination means of claim 1; and

a center front speaker located in front of the listening location,

wherein said fifth audio output signal is transmitted to and reproduced by said center front speaker,

such that the reproduced sound associated with said fifth audio output signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from approximately the location of said center front speaker.

30. The audio reproduction system of claim 1, further comprising:

signal format detection means for determining the format of the at least four audio input signals; and

switching means for disconnecting the first and fourth audio input signals and for altering the signal path of the second and third audio input signals,

such that, upon determination that only the second and third audio input signals are active, said switching means operates to disconnect the first and fourth audio signals from the signal modification and combination means and to reconnect the second and third audio input signals to the signal modification and combination means in the locations previously occupied by the first and fourth audio input signals, respectively, so as to bypass any front-to-back filters in the new signal paths for the second and third audio input signals,

such that said second and third audio input signals are substituted for said first and fourth audio signals, respectively, in the difference signals transmitted to and reproduced by the left and right sub-speakers,

such that sound reproduced by the system associated with said second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers.

31. A method for producing phantom surround sound effect from a loudspeaker system located in front of a listener, comprising the steps of:

providing a left main speaker and a right main speaker intended to be disposed respectively at left and right main speaker locations spaced along a speaker axis defined as a line passing through said left and right main speaker locations, with a listening area comprising the general area in front of the left and right main speaker locations such that the left main speaker location lies to the left and the right main speaker location lies to the right when viewed from the listening area;

providing a left sub-speaker and a right sub-speaker intended to be disposed respectively at left and right sub-speaker locations, wherein the intended left and right sub-speaker locations are intended to lie approximately on the speaker axis such that the left and right sub-speaker locations as viewed from the listening area are located to the left and right respectively of the respective left and right main speaker locations and are spaced a distance  $d$  from the respective left and right main speaker locations such that the distance  $d$  is in the range from approximately 50% to 150% of the average spacing between a person's ears as measured in a straight line through the head;

modifying a first audio input signal and combining the modified first audio input signal with a second audio input signal, transmitting the combination of the modified first audio input signal and the second audio input signal to the left main speaker, and reproducing sound associated with the combination of the modified first audio input signal and the second audio input signal in the left main speaker;

modifying a fourth audio input signal and combining the modified fourth audio input signal with a third audio input signal, transmitting the combination of the



modified fourth audio input signal and the third audio input signal to the right main speaker, and reproducing the sound associated with the combination of the modified fourth audio input signal and the third audio input signal in the right main speaker;

subtracting the modified fourth audio input signal from the modified first audio input signal, transmitting the resulting difference signal to the left sub-speaker, and reproducing sound associated with the difference signal in the left sub-speaker; and

subtracting the modified first audio input signal from the modified fourth audio input signal, transmitting the resulting difference signal to the right sub-speaker, and reproducing sound associated with the difference signal in the right sub-speaker;

wherein the reproduced sound associated with the second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a range of sound locations approximately between said left and right main speakers, and

wherein the reproduced sound associated with the first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers.

32. The method of claim 31 further comprising the steps of:

providing a center front speaker intended to be located between the left and right main speaker locations; and

transmitting a fifth audio input signal to the center front speaker and reproducing sound associated with the fifth audio input signal in the center front speaker,

wherein the reproduced sound associated with the fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from approximately the location of said center front speaker.

33. The method of claim 31 or 32, wherein the distance  $d$  between the respective main and sub-speakers is approximately equal to the average ear spacing.

34. The method of claim 31, wherein said step of modifying the first audio input signal comprises using a first front-to-back filter and said step of modifying the fourth audio input signal comprises using a second front-to-back filter, such that the reproduced sound associated with the first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers including areas behind the listener.

35. The method of claim 31 or 32, wherein the first audio input signal, the second audio input signal, the third audio input signal, and the fourth audio input signal correspond to front left, front right, rear left, and rear right signals of a surround sound audio system.

36. The method of claim 34, further comprising the step of band limiting the first and second front-to-back filters to below approximately 2,500 Hz.

37. The method of claim 34, wherein the first and second front-to-back filters include band emphasis at approximately 12 kHz.

38. The method of claim 31 or 32, further comprising the steps of:  
limiting the frequency response of the portion of the modified first audio input signal transmitted to the left sub-speaker to below a certain frequency; and  
limiting the frequency response of the portion of the modified fourth audio input signal transmitted to the right sub-speaker to below a certain frequency,  
wherein the apparent sound locations of the reproduced sound associated with the first and fourth audio input signals are perceived by a listener located in the listening area to be more stable and more tolerant of movements of the listener's head.

39. The method of claim 38, wherein the frequency response of the portion of the modified first and fourth audio input signals is limited to below approximately 5 kHz.

40. The method of claim 38, wherein the frequency response of the portion of the modified first and fourth audio input signals is limited to below approximately 1.8 kHz.

41. The method of claim 38, wherein the frequency response of the portion of the modified first and fourth audio input signals is limited to below approximately 1 kHz.

42. The method of claim 38, further comprising the steps of:

limiting the frequency response of the portion of the modified first audio input signal subtracted from the modified fourth audio input signal to below a certain frequency; and

limiting the frequency response of the portion of the modified fourth audio input signal subtracted from the modified first audio input signal to below a certain frequency,

wherein the reproduced sound associated with the first and fourth audio input signals are perceived by a listener located in the listening area to be more stable and more tolerant of movements of the listener's head.

43. The method of claim 31 or 32, further comprising the steps of:

limiting the frequency response of the portion of the modified first audio input signal which is subtracted from the modified fourth audio input signal to above a certain frequency prior to transmission to the right sub-speaker; and

limiting the frequency response of the portion of the modified fourth audio input signal which is subtracted from the modified first audio input signal to above a certain frequency prior to transmission to the left sub-speaker,

wherein the resulting signals received by the left and right sub-speakers have low-frequency content primarily composed of information only from the first and fourth audio input signals, respectively.

44. The method of claim 31, further comprising the step of:

combining a fifth audio input signal with the signals being received by the left and right main speakers such that, in addition to the signals specified in claim 31,

approximately equal quantities of the fifth audio input signal are transmitted to and reproduced by the left and right main speakers,

wherein the reproduced sound associated with the fifth audio input signal is perceived by a listener located in the listening area to originate approximately from a location equidistant between the left and right main speakers.

45. The method of claim 44, further comprising the steps of:

modifying a sixth audio input signal using a front-to-back filter;

combining the modified sixth audio input signal with the signals being received by the left and right main speakers such that, in addition to the signals specified in claim 44, approximately equal quantities of the modified sixth audio input signal are transmitted to and reproduced by the left and right main speakers,

wherein the reproduced sound associated with the sixth audio input signal is perceived by a listener located in the listening area to originate from a location generally behind the listener.

46. The method of claim 34, further comprising the steps of:

combining the second audio input signal with the first audio input signal after modification of said first audio input signal by the first front-to-back filter;

combining the third audio input signal with the fourth audio input signal after modification of said fourth audio input signal by the second front-to-back filter;

subtracting the combination of the modified fourth audio input signal and the third audio input signal from the combination of the modified first audio input signal and the second audio input signal, transmitting the resulting difference signal to the left sub-speaker, and reproducing the difference signal in the left-sub-speaker; and

subtracting the combination of the modified first audio input signal and the second audio input signal from the combination of the modified fourth audio input signal and the third audio input signal, transmitting the resulting difference signal to the right sub-speaker, and reproducing the difference signal in the right sub-speaker,

wherein the reproduced sound associated with the second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations generally in front of the listener location and extending beyond said left and right sub-speakers, and

wherein the reproduced sound associated with the first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers and including the area behind the listener.

47. The method of claim 46, further comprising the steps of:

limiting the frequency response of the portion of the combined modified first and second audio input signal transmitted to the left sub-speaker to below a certain frequency; and

limiting the frequency response of the portion of the combined modified third and fourth audio input signal transmitted to the right sub-speaker to below a certain frequency,

wherein the apparent sound locations of the reproduced sound associated with the first, second, third and fourth audio input signals are perceived by a listener located in

the listening area whose head is oriented generally toward the speaker locations to be more stable and more tolerant of movements of the listener's head.

48. The method of claim 47, wherein the frequency response of the portion of the combined modified first and second audio input signal transmitted to the left sub-speaker and the frequency response of the combined modified third and forth audio input signal transmitted to the right sub-speaker are limited to below approximately 5KHz.

49. The method of claim 47, wherein the frequency response of the portion of the combined modified first and second audio input signal transmitted to the left sub-speaker and the frequency response of the combined modified third and forth audio input signal transmitted to the right sub-speaker are limited to below approximately 1.8 kHz.

50. The method system of claim 47, wherein the frequency response of the portion of the combined modified first and second audio input signal transmitted to the left sub-speaker and the frequency response of the combined modified third and forth audio input signal transmitted to the right sub-speaker are limited to below approximately 1 kHz.

51. The method of claim 47, further comprising the steps of:

limiting the frequency response of that portion of the combined modified first and second audio input signal subtracted from the combined modified third and fourth audio input signal to below a certain frequency; and

limiting the frequency response of that portion of the combined modified third and fourth audio input signal subtracted from the combined modified first and second audio input signal to below a certain frequency,

wherein the apparent sound locations of the reproduced sound associated with the first, second, third and fourth audio input signals are perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to be more stable and more tolerant of movements of the listener's head.

52. The method of claim 46, further comprising the steps of:

limiting the frequency response of that portion of the combined modified first and second audio input signals which is subtracted from the combined modified third and fourth audio input signals to above a certain frequency prior to reproduction by the right sub-speaker; and

limiting the frequency response of that portion of the combined modified third and fourth audio input signals which is subtracted from the combined modified first and second audio input signals to above a certain frequency prior to reproduction by the left sub-speaker,

wherein the resulting signal received by the left sub-speaker has low-frequency content primarily composed of information only from the combined modified first and second audio input signals, and

wherein the resulting signal received by the right sub-speaker has low-frequency content primarily composed of information only from the combined and modified third and fourth audio input signals.



53. The method of claim 46, further comprising the step of combining a fifth audio input signal with the signals being received by the left and right main speakers such that, in addition to the signals specified in claim 46, approximately equal quantities of the fifth audio input signal are transmitted to and reproduced by the left and right main speakers,

wherein the reproduced sound associated with the fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate approximately from a location equidistant between the left and right main speakers.

54. The method of claim 53, further comprising the steps of:

modifying a sixth audio input signal using a front-to-back filter; and

combining the modified sixth audio input signal with the signals being received by the left and right main speakers such that, in addition to the signals specified in claim 53, approximately equal quantities of the sixth audio input signal are transmitted and reproduced by the left and right main speakers,

wherein the reproduced sound associated with the sixth audio input signal is perceived by a listener whose head is located generally at the listening location to originate from a location generally behind the listener.

55. A method for producing phantom surround sound effect from a loudspeaker system located in front of a listener, comprising the steps of:

providing a left main speaker and a right main speaker intended to be disposed respectively at left and right main speaker locations spaced along a speaker axis defined as a line passing through said left and right main speaker locations, with a

listening area comprising the general area in front of the left and right main speaker locations such that the left main speaker location lies to the left and the right main speaker location lies to the right when viewed from the listening area;

providing a left front speaker and a right front speaker intended to be disposed generally in front of a listener in the listening area;

providing a left sub-speaker and a right sub-speaker intended to be disposed respectively at left and right sub-speaker locations, wherein the intended left and right sub-speaker locations are intended to lie approximately on the speaker axis such that the left and right sub-speaker locations as viewed from the listening area are located to the left and right respectively of the respective left and right main speaker locations and are spaced a distance  $d$  from the respective left and right main speaker locations such that the distance  $d$  is in the range from approximately 50% to 150% of the average spacing between a person's ears as measured in a straight line through the head;

modifying a first audio input signal, transmitting the modified first audio input signal to the left main speaker, and reproducing sound associated with the modified first audio input signal in the left main speaker;

modifying a fourth audio input signal, transmitting the modified fourth audio input signal to the right main speaker, and reproducing the sound associated with the modified fourth audio input signal in the right main speaker;

transmitting a second audio input signal to the left front speaker and reproducing sound associated with the second audio input signal in the left front speaker;

transmitting a third audio input signal to the right front speaker and reproducing sound associated with the third audio input signal in the right front speaker;

subtracting the modified fourth audio input signal from the modified first audio input signal, transmitting the resulting difference signal to the left sub-speaker, and reproducing sound associated with the difference signal in the left sub-speaker; and

subtracting the modified first audio input signal from the modified fourth audio input signal, transmitting the resulting difference signal to the right sub-speaker, and reproducing sound associated with the difference signal in the right sub-speaker;

wherein the reproduced sound associated with the second and third audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a range of sound locations approximately between the left front speaker and the right front speaker.

wherein the reproduced sound associated with the first and fourth audio input signals is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from a broad range of sound locations extending beyond the locations of said left and right sub-speakers.

56. The method of claim 55, further comprising the steps of:

combining a fifth audio signal input with the signals being received by the left front speaker and the right front speaker such that in addition to the signals specified in claim 55, approximately equal quantities of the fifth audio input signal are transmitted to and reproduced by the left and right front speakers,

wherein the reproduced sound with the fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate approximately from a location equidistant between the left and right front speakers.

57. The method of claim 56, further comprising the steps of:

modifying a sixth audio input signal using a front-to-back filter; and

combining the modified sixth audio input signal with the signals being received by the left front speaker and the right front speaker, such that in addition to the signals specified in claim 56, approximately equal quantities of the modified sixth audio input signal are transmitted and reproduced by the second left and right front speakers,

wherein the reproduced sound associated with the sixth audio input signal is perceived by a listener whose head is located generally at the listening location to originate from a location generally behind the listener.

58. The method of claim 31 or 46, further comprising the step of:

converting a two-channel audio input signal to into a multi-channel audio output comprising at least four audio output signals, wherein the at least four audio output signals are the first audio input signal, the second audio input signal, the third audio input signal, and the fourth audio input signal of claim 31 or 46.

59. The method of claim 31 or 46, further comprising the steps of:

converting a two-channel audio input signal into a multi-channel audio output comprising five audio output signals;

transmitting four of the five audio output signals such that they are the first audio input signal, the second audio input, the third audio input signal, and the fourth audio input signal;

transmitting the fifth audio output signal such that it is a fifth audio input signal reproduced by a center front speaker;

wherein the reproduced sound associated with the fifth audio input signal is perceived by a listener located in the listening area whose head is oriented generally toward the speaker locations to originate from approximately the location of said center front speaker.